

## WHAT IS CLAIMED IS:

1. A method for fabricating a semiconductor device having a ferroelectric capacitor in which a lower electrode, a ferroelectric thin film constructed of at least three layers, and an upper electrode are successively laminated on a substrate, comprising the steps of:

crystallizing an intermediate layer between a lowermost layer and an uppermost layer among the layers of the ferroelectric thin film by performing heat treatment for the intermediate layer at a first temperature for a first setting time; and

crystallizing at least one of the lowermost layer and the uppermost layer by performing heat treatment at a second temperature lower than the first temperature.

15 2. A semiconductor device fabricating method as claimed in claim 1, wherein

both the lowermost layer and the uppermost layer are crystallized by performing heat treatment at the second temperature.

20 3. A semiconductor device fabricating method as claimed in claim 2, wherein

a heat treatment time of the lowermost layer and the uppermost layer of the ferroelectric thin film is the first setting time.

25 4. A semiconductor device fabricating method as

claimed in claim 1, wherein

the lowermost layer is crystallized by performing  
heat treatment at the second temperature, and

5       the uppermost layer is crystallized by performing  
heat treatment for a second setting time shorter than the  
first setting time at the first temperature.

5.       A semiconductor device fabricating method as  
claimed in claim 4, wherein

a heat treatment time for crystallizing the  
lowermost layer is the first setting time, and

10       a heat treatment temperature for crystallizing  
the uppermost layer is the first temperature.

6.       A semiconductor device fabricating method as  
claimed in claim 1, wherein

15       the lowermost layer is crystallized by performing  
heat treatment for a second setting time shorter than the  
first setting time, and

the uppermost layer is crystallized by performing  
heat treatment at the second temperature.

20       7.       A semiconductor device fabricating method as  
claimed in claim 6, wherein

a heat treatment temperature for crystallizing  
the lowermost layer is the first temperature, and

25       a heat treatment time for crystallizing the  
uppermost layer is the first setting time.

8. A method for fabricating a semiconductor device having a ferroelectric capacitor in which a lower electrode, a ferroelectric thin film constructed of at least three layers, and an upper electrode are successively laminated on a substrate, comprising the steps of:

crystallizing an intermediate layer between a lowermost layer and an uppermost layer among the layers of the ferroelectric thin film by performing heat treatment for the intermediate layer at a first temperature for a first setting time; and

crystallizing at least one of the lowermost layer and the uppermost layer by performing heat treatment at the first temperature or a second temperature lower than the first temperature for a second setting time shorter than the first setting time.

9. A semiconductor device fabricating method as claimed in claim 8, wherein

both the lowermost layer and the uppermost layer are crystallized by performing heat treatment for the second setting time.

10. A semiconductor device fabricating method as claimed in claim 9, wherein

a heat treatment temperature of the lowermost layer and the uppermost layer is the first temperature.

25 11. A semiconductor device fabricating method as

claimed in claim 1, wherein

the first temperature is a temperature being higher than 700°C and not higher than 800°C.

12. A semiconductor device fabricating method as claimed in claim 8, wherein

the first temperature is a temperature being higher than 700°C and not higher than 800°C.

13. A semiconductor device fabricating method as claimed in claim 1, wherein

10 the second temperature is within a range of 600°C to 700°C.

14. A semiconductor device fabricating method as claimed in claim 8, wherein

15 the second temperature is within a range of 600°C to 700°C.

16. A semiconductor device fabricating method as claimed in claim 1, wherein

the first setting time is longer than 10 minutes and not longer than 60 minutes.

20 16. A semiconductor device fabricating method as claimed in claim 8, wherein

the first setting time is longer than 10 minutes and not longer than 60 minutes.

17. A semiconductor device fabricating method as 25 claimed in claims 4, wherein

the second setting time is within a range of five minutes to 10 minutes.

18. A semiconductor device fabricating method as claimed in claims 4, wherein

5 the second setting time is within a range of five minutes to 10 minutes.

19. A semiconductor device fabricating method as claimed in claim 1, wherein

10 the ferroelectric thin film is a ferroelectric substance of a Bi layer structure.

20. A semiconductor device fabricating method as claimed in claim 1, wherein

the ferroelectric thin film is formed by coating.

21. A semiconductor device fabricating method as 15 claimed in claim 1, wherein

a film forming method of the ferroelectric thin film is an LSMCD method.

22. A semiconductor device fabricating method as claimed in claim 21, wherein

20 the intermediate layer is crystallized by repeating processes for performing deposition and tentative baking at a third temperature a plurality of times and performing heat treatment at the first temperature for the first setting time.

25 23. A semiconductor device having a ferroelectric

(sub B1)

capacitor comprising:

a lower electrode laminated on a substrate;  
a ferroelectric thin film laminated on the lower  
electrode and constructed of at least three layers  
including a lowermost layer, a uppermost layer and an  
intermediate layer located between the lowermost layer and  
the uppermost layer; and

an upper electrode laminated on the ferroelectric  
thin film,

wherein a crystal grain of at least one of the  
lowermost layer and the uppermost layer is smaller than a  
crystal grain of the intermediate layer.

24. A semiconductor device as claimed in claim 23,

wherein

15 a crystal grain of the lowermost layer and a  
crystal grain of the uppermost layer is smaller than a  
crystal grain of the intermediate layer.

25. A method for fabricating a semiconductor device  
having a ferroelectric capacitor in which a lower electrode,  
20 a ferroelectric thin film constructed of at least three  
layers, and an upper electrode are successively laminated  
on a substrate, comprising the step of:

crystallizing the lowermost layer of the  
ferroelectric thin film by laser annealing.

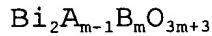
25 26. A method for fabricating a semiconductor device

having a ferroelectric capacitor in which a lower electrode, a ferroelectric thin film constructed of at least three layers, and an upper electrode are successively laminated on a substrate, comprising the step of:

5           crystallizing the lowermost layer of the ferroelectric thin film by rapid thermal annealing with infrared ray heating.

27.          A semiconductor device fabricating method as claimed in claim 25 or 26, wherein

10           the ferroelectric thin film is made of a material expressed by:



where A represents one selected from a group consisting of Na, K, Pb, Ca, Sr, Ba and Bi,

15          B represents one selected from a group consisting of Fe, Ti, Nb, Ta, W and Mo, and

m represents a natural number.

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28.          A semiconductor device having a ferroelectric capacitor comprising:

20           a lower electrode laminated on a substrate;

              a ferroelectric thin film laminated on the lower electrode, constructed of at least three layers including a lowermost layer, an uppermost layer and an intermediate layer located between the lowermost layer and the uppermost layer; and

an upper electrode laminated on the ferroelectric thin film,  
wherein  
5 a crystalline nucleus density of the lowermost layer is higher than those of other layers than the lowermost layer.

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Add B3